Integration of Airborne Aerosol Prediction Systems and Vegetation Phenology to Track Pollen for Asthma Alerts in Public Health Decision Support Systems

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Decision Support Model

Earth System Models:

Pollen REgional Atmospheric Model (PREAM)

Earth Observations:

MODIS-pollen signal
Landsat- Juniper type

Ground Measurements:

Phenology

Juniper forest types

Pollen- Tauber Traps, Burkard samplers

Regional Climate

Decision Support:

EPHTN – New Mexico
SYRIS – Southwest, OK & TX

Benefits:

Alert public health Systems to:

Pollen Sources
Pollen Release Timing
Pollen Dispersion

Limitations of Pollen Sampling

- Lack of stations
- Count frequency & reporting lag time
- Different sampling instruments Rotorod Sampler/Burkard Spore Trap
- Only indentifiable pollen "grains"
- Expertise in counting/indentification
- Refusal to release sampling information-"*We do not reveal the sources for our data for privacy and proprietary, competitive reasons. Some pollen counts are conducted privately, and are not meant to be broadcast to the public*"

PollenCast for Tucson, Arizona

Tree | Grass | Weed

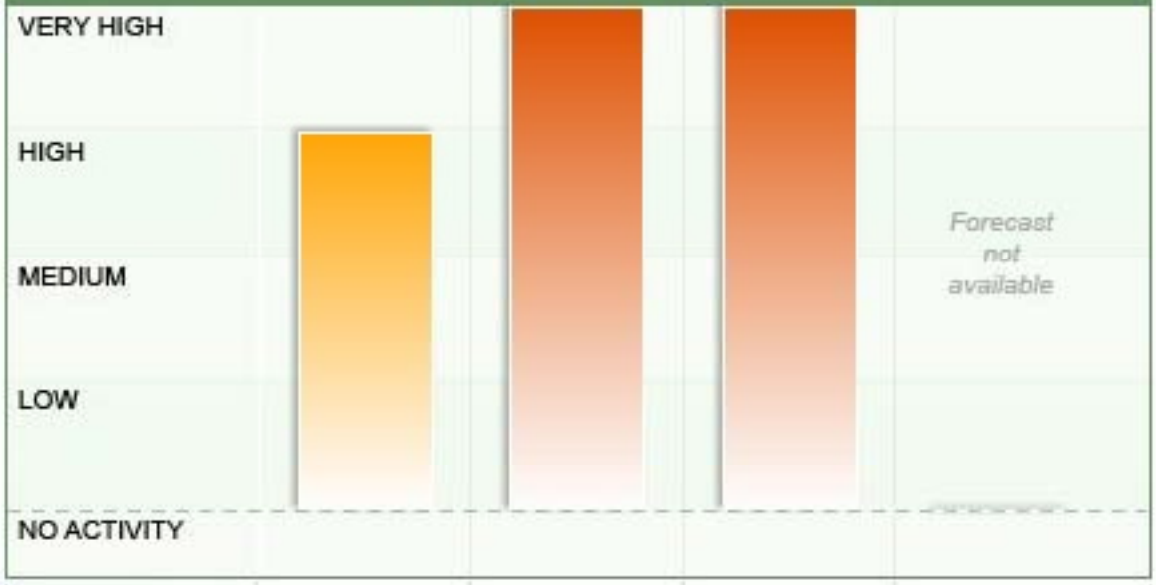
Reported Levels

Tree pollen count for today, 03/31/08:

Moderate

See past pollen counts for Tucson, Arizona

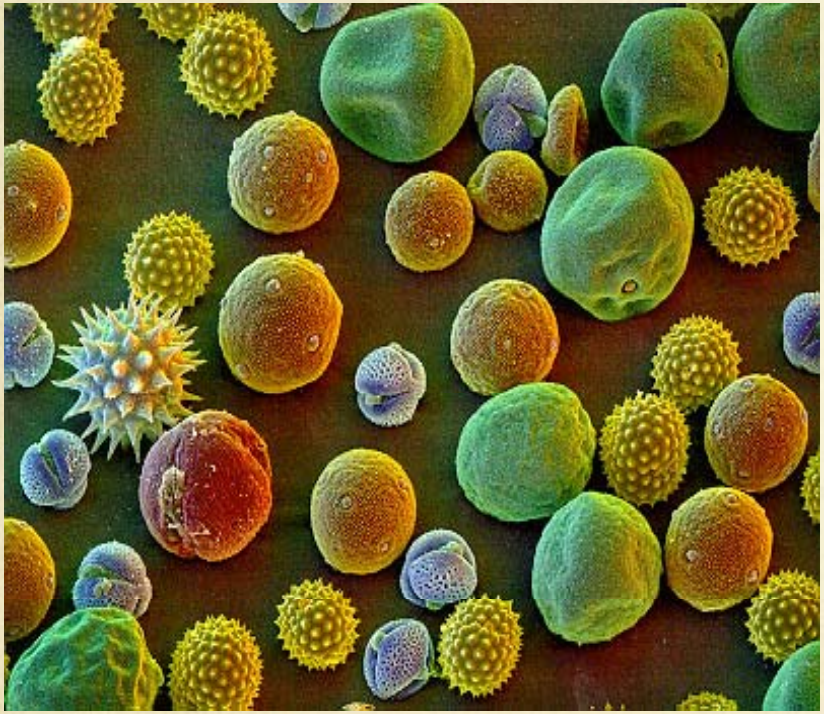
Forecasted Levels



Pollen Timing

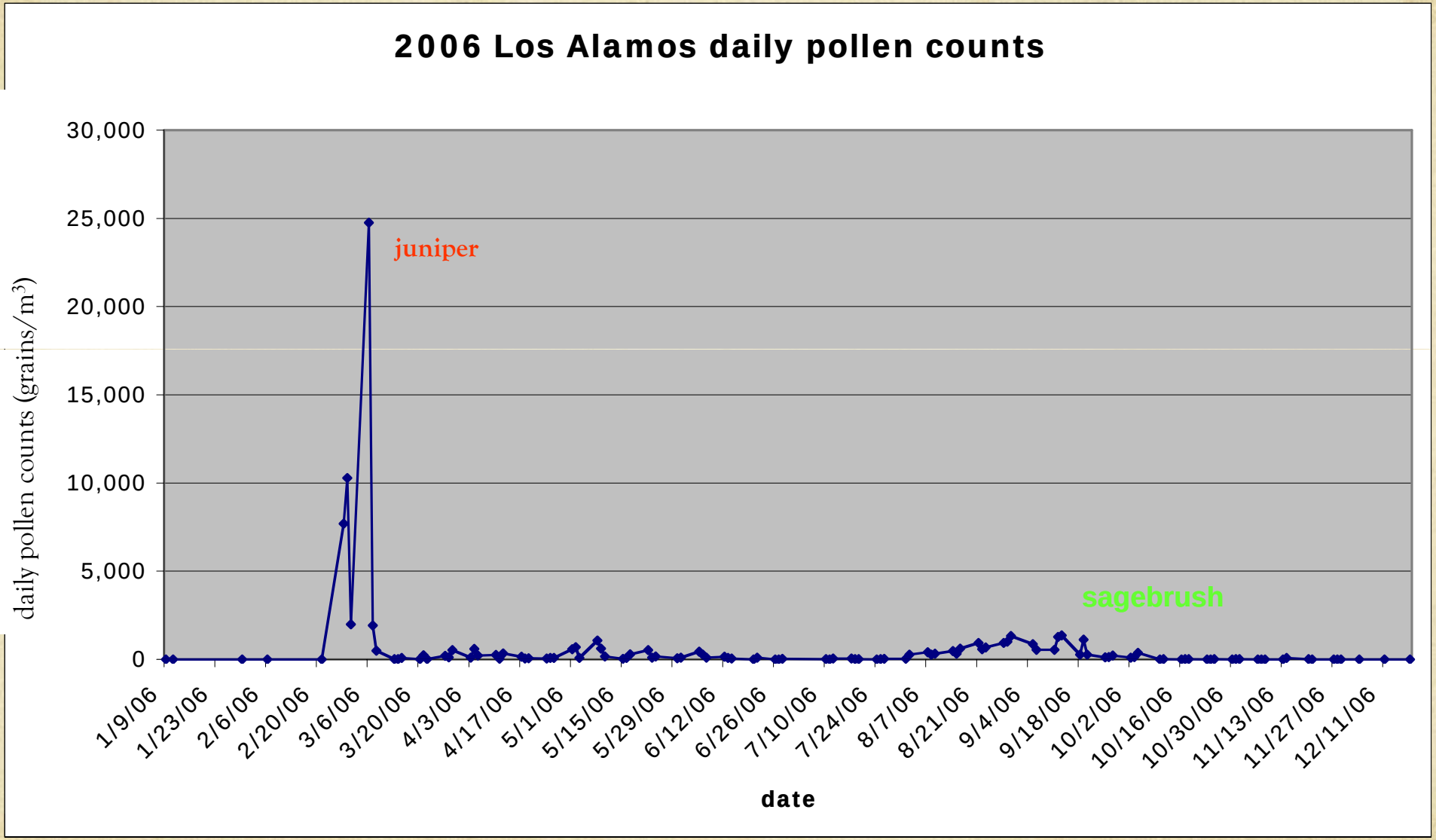
- *Growing Degree Days* - the average of the daily maximum and minimum temperatures compared to a base temperature, T_{base}, (usually 10 °C)
- Response to length of day
- Species differences
- Climate
- Weather

Top pollen-producing species



Los Alamos	Albuquerque
juniper	mulberry
sagebrush	juniper
pine	ash
Alternaria*	goosefoot
oak	cottonwood
grass	grass
ragweed	sagebrush
goosefoot	pine
Cladosporium*	elm
Myxomycete*	aster
cottonwood	ragweed
mulberry	sycamore
aster	oak
elm	willow

*fungal / slime mold spores


2006 Los Alamos daily pollen counts
daily pollen counts (grains/m3)
30,000
25,000
20,000
15,000
10,000
5,000
0
juniper
sagebrush
1/9/06
1/23/06
2/6/06
2/20/06
3/6/06
3/20/06
4/3/06
4/17/06
5/1/06
5/15/06
5/29/06
6/12/06
6/26/06
7/10/06
7/24/06
8/7/06
8/21/06
9/4/06
9/18/06
10/2/06
10/16/06
10/30/06
11/13/06
11/27/06
12/11/06
date

Top pollen-producing species and their pollen/spore sizes

SPECIES	SIZE (µm)
Myxomycete*	5-15
Cladosporium*	16-18
Alternaria*	15-90
mulberry	15-25
aster	18-25
ash	18-28
ragweed	19-20
sagebrush	19-24
juniper	20-30
oak	20-35
grass	20-100
goosefoot	20-35
willow	24
cottonwood	25-35
elm	25-35
pine	45-85

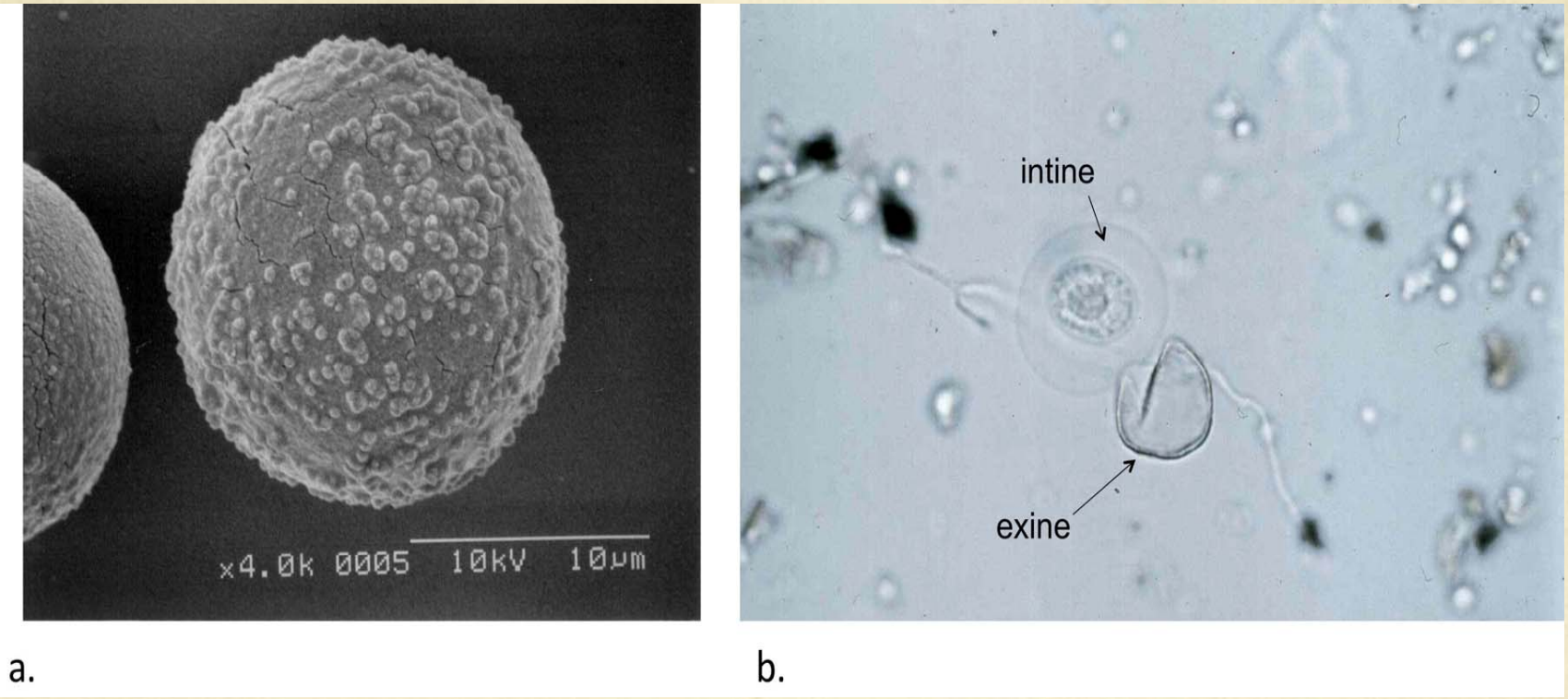


Fig. a. Juniperus virginiana pollen grain. b. Response of Juniperus sp. pollen grain to hydration were the interior germ plasma (intine) separates from the outer wall (exine).

Pollen and Respiratory Disease: What little is known[2]

Increase in mortality of these disorders:

	Poaceae pollen concentrations (grains per m^3 air)			
	<22	22–77	78–135	>135
	Relative risk	Relative risk (95% CI)	Relative risk (95% CI)	Relative risk (95% CI)
Cardiovascular disease	1·000	1·015 (1·002–1·029)	1·012 (0·994–1·029)	1·061 (1·038–1·084)
Chronic obstructive pulmonary disease	1·000	1·095 (1·053–1·139)	1·124 (1·069–1·181)	1·150 (1·079–1·225)
Pneumonia	1·000	1·104 (1·049–1·163)	1·093 (1·023–1·168)	1·168 (1·077–1·266)
Total	1·000	1·019 (1·010–1·028)	1·019 (1·008–1·031)	1·043 (1·028–1·058)

- High concentrations of pollen allergens have also been shown to occur in thoracic particles (<10 microns in diameter) and respirable particles (<2·5 microns and these correlated well in time with airborne pollen concentrations. … airborne pollen results in exposure of the lower airways and lung to pollen allergens.

- The association between air pollution and the number of daily deaths may be related to the inflammatory potential of very small particles

- …suggests that high airborne pollen concentrations, which nowadays are mainly seen as triggers of allergic symptoms, may have far more serious effects than previously thought."

[2] Bert Brunekreef, Gerard Hoek, Paul Fischer, Frits Th M Spieksma. Relation between airborne pollen concentrations and daily cardiovascular and respiratory-disease mortality. Lancet Vol 355 (2000): 1517-8.

March 2008

Airborne Dust Simulations and Forecasts

University of Arizona

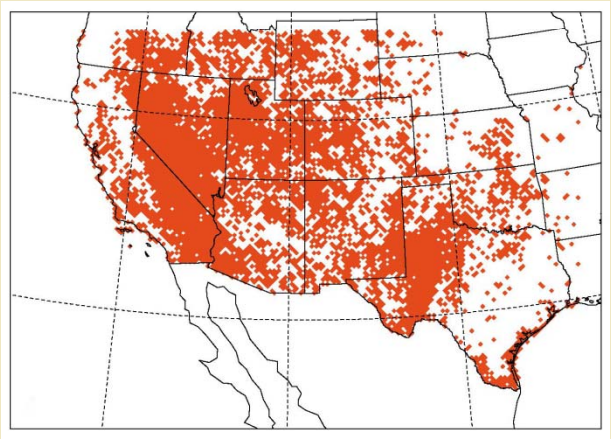
With NASA Earth System Science & University of New Mexico

Department of Atmospheric Sciences

http://www.atmo.arizona.edu/faculty/research/dust/dust.html

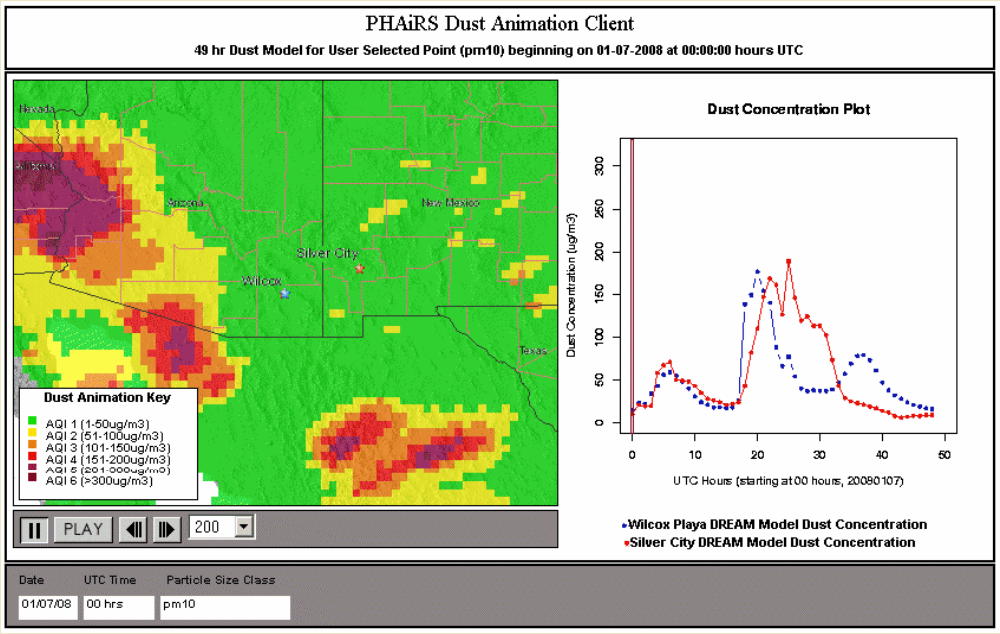
Phenology and Pollen Transport

NASA Remote Sensing



Currently – dust source regions
Future – pollen sources derived from phenological maps

DREAM – UofA numerical meteorological particulate transport model



Final Product – predicted concentrations of pollen in time and space

http://www.atmo.arizona.edu/research/dust/dust.html

PHENOLOGY as an INTEGRATIVE SCIENCE for ASSESSMENT of GLOBAL CHANGE IMPACTS

Jake F. Weltzin and Mark Losleben

USA National Phenology Network, National Coordinating Office, Tucson, Arizona

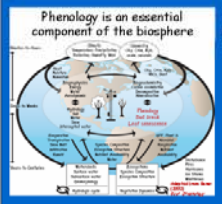
A National Phenology Network

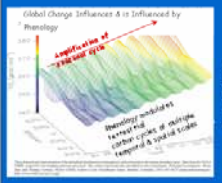
Phenology is the study of periodic plant and animal life cycle events and how these are influenced by seasonal and interannual variations in climate. Examples include the timing of leafing and flowering, agricultural crop stages, insect emergence, and animal migration. All of these events are sensitive measures of climatic variation and change, are relatively simple to record and understand, and are vital to both the scientific and public interest.

Phenology can be used as a predictor for a variety of processes and variables of importance at local to global scales. Phenology modulates the abundance and diversity of organisms, their inter-specific interactions, their ecological functions, and their effects on fluxes in water, energy, and chemical elements at various scales. Phenological data and models are useful in agriculture, drought monitoring, and wildfire risk assessment, as well as management of invasive species, pests, and infectious diseases. **Integration of spatially-extensive phenological data and models with both short and long-term climatic forecasts offer a powerful agent for human adaptation to ongoing and future climate change.** To fully utilize the value in phenological data, however, a new data resource is required – *a large-scale network of integrated phenological observations, linked with other relevant data sources, and the tools to analyze these data at multiple scales.*

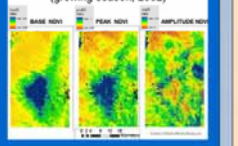
A USA National Phenology Network (USA-NPN) is currently being designed and organized to engage federal agencies, environmental networks and field stations, educational institutions, and mass participation by citizen scientists.

PHENOLOGY: THE PULSE OF OUR PLANET





Spatial patterns of Pheno-metrics (growing season; 2002)



USA-NPN Collaboration Plan

GOALS

-To advance the USA-NPN scientific mission to understand and predict shifts in phenological cycles due to climate change and natural variability.

-benefit from and contribute to many existing organizations that are concerned about nature and climate.

-Maximize resources through close collaboration with organizations. This represents not only the best use of available resources but also the best scientific practice.

PLAN

-Coordinate research activities with existing networks to advance phenological science and develop mechanistic phenological models to support improvement of climate and ecosystem models.

-Maximize the representation of phenological monitoring sites at the national and regional scale to enable biological baseline characterization and trend detection.

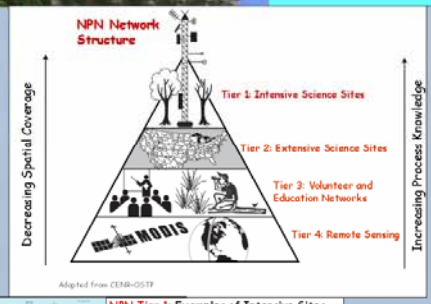
- Provide data and information to policy makers to support land management decisions in regard to the mitigation of climate change impacts.

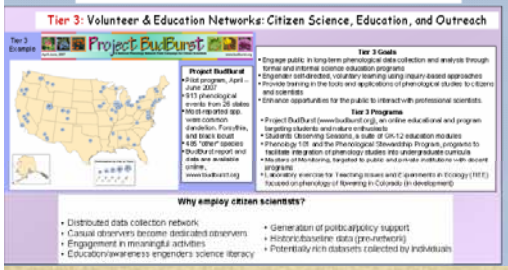
PRIORITIES

- Establish coordination between NPN and existing networks
- Identify constraints and needs of existing networks and develop tailored collaborative items suitable for each network
- Nurture common interests/develop collaborative research projects
- Organize joint workshops
- Distribute NPN newsletters

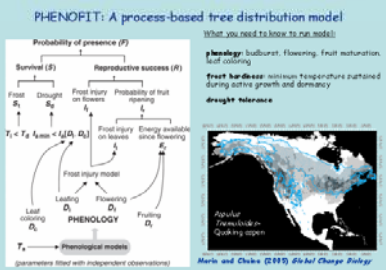
PRINCIPLES

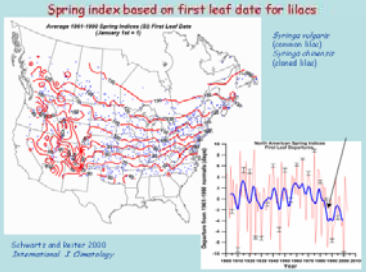
- Mutually beneficial activities
- Shared vision on science / education / outreach
- Minimizing the demand on the capacities of partners
- Feedback to improve collaboration
- Transparent data and information sharing policy

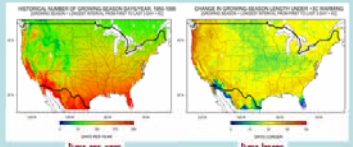


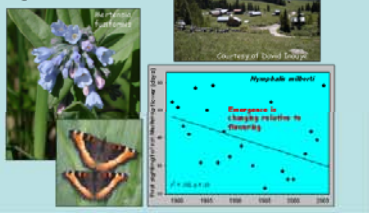


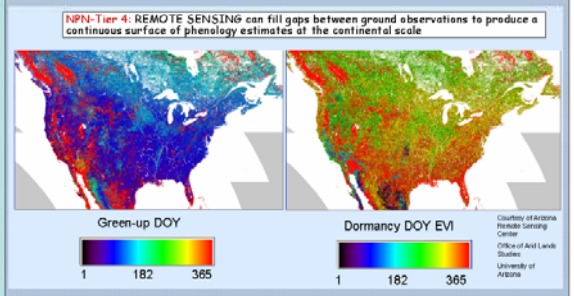
Integration of spatially-extensive phenological data and models with both short and long-term climatic forecasts offer a powerful agent for human adaptation to ongoing and future climate change.











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1955 E. Sixth Street
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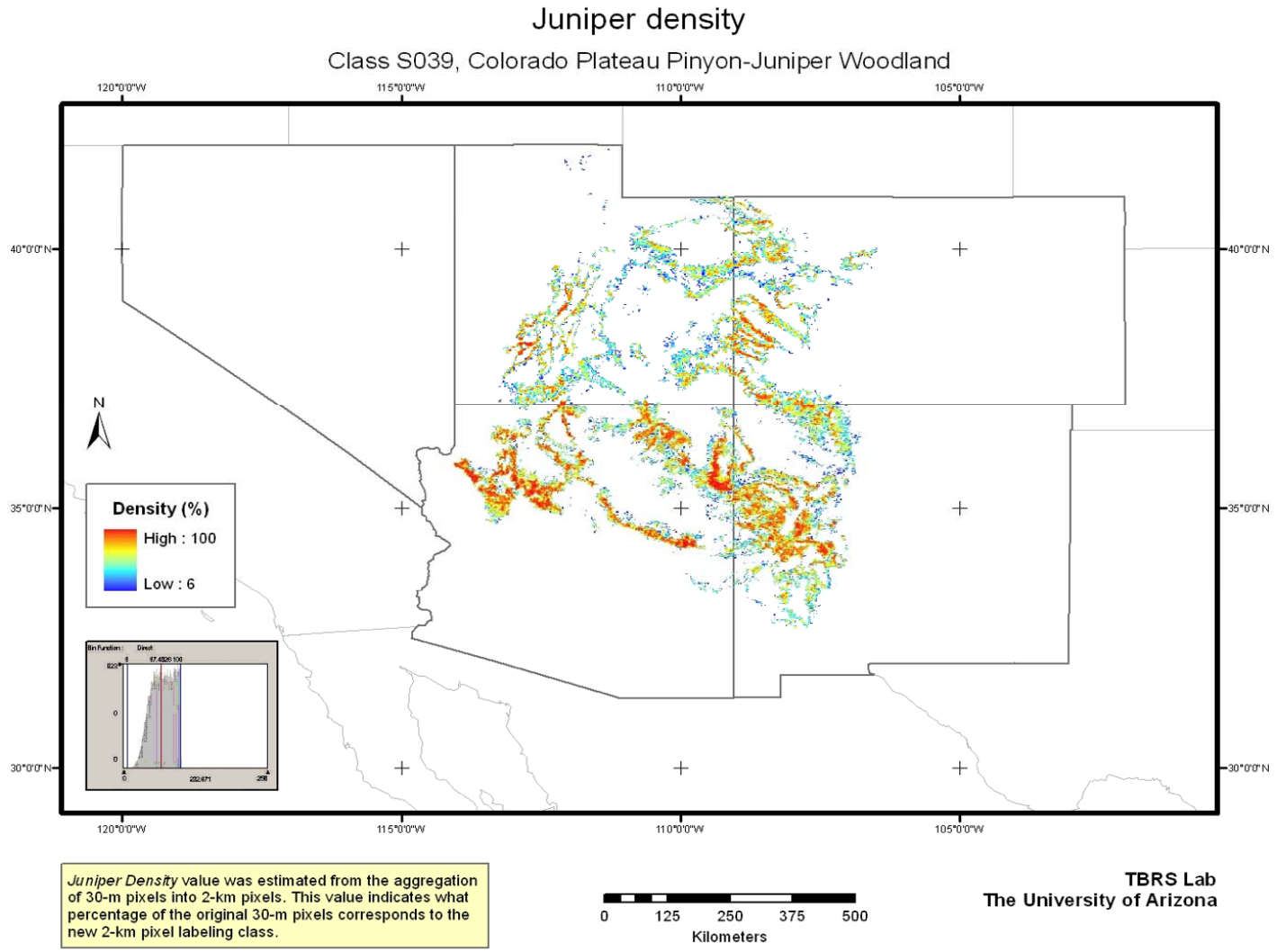
Juniper land cover classes analyzed intensively with MODIS satellite data.

Land Cover Class Codification

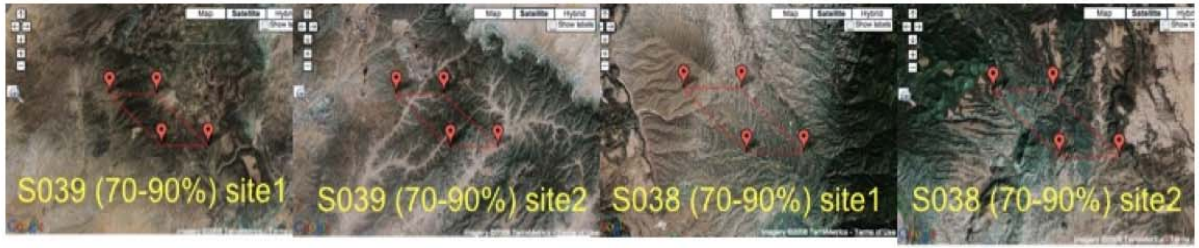
GAP Class	Class Id	Internal Code
Southern Rocky Mountain Pinyon-Juniper Woodland	S038	35
Colorado Plateau Pinyon-Juniper Woodland	S039	36
Southern Rocky Mountain Juniper Woodland and Savanna	S074	63
Madrean Pine-Oak Forest and Woodland	S035	33
Madrean Pinyon-Juniper Woodland	S112	92
Inter-Mountain Basins Juniper Savanna	S075	64
Madrean Juniper Savanna	S115	95

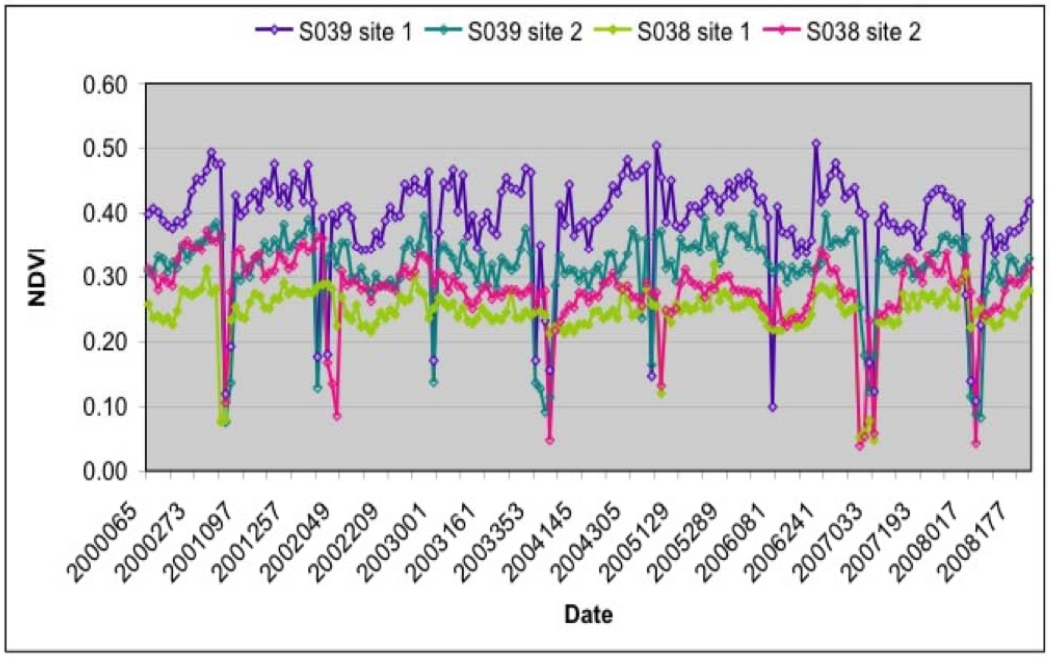


Percent Juniper density for land cover class SO39.

MODIS data products downloaded and analyzed for this study.

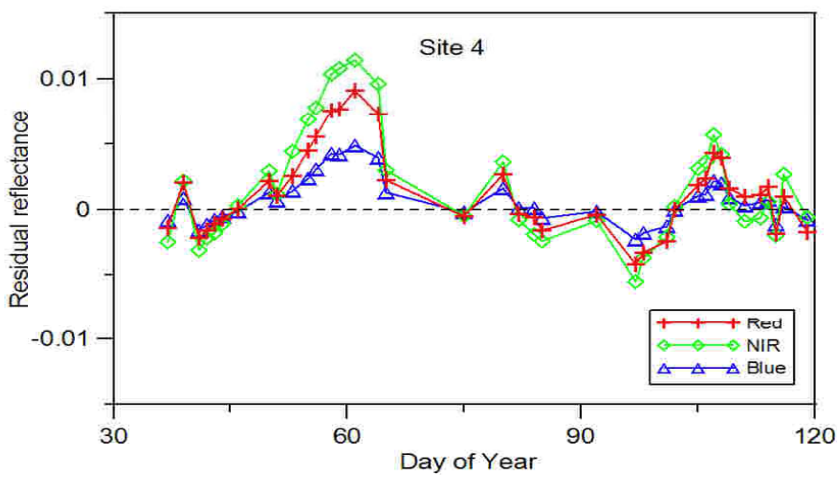
Data Product	Spacecraft/ Sensor	Temporal/ Spatial resolution
Level 3 Surface reflectance, MOD09, version 5	Terra, Aqua MODIS	8-day/ 500 m
Level 2G Surface reflectance, MOD09GA, version 5	Terra, Aqua MODIS	**Daily**/ 250 m, 500 m
Level 3 Vegetation Indices, MOD13Q1, version 5	Terra, Aqua MODIS	8-day (combined), 250 m
Vegetation Indices, computed from level 2G MOD09GA	Terra, Aqua MODIS	Daily/ 250 m

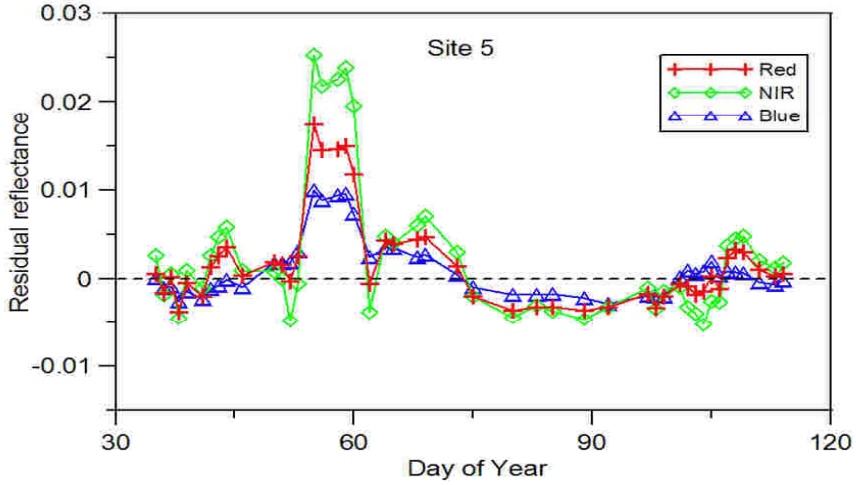


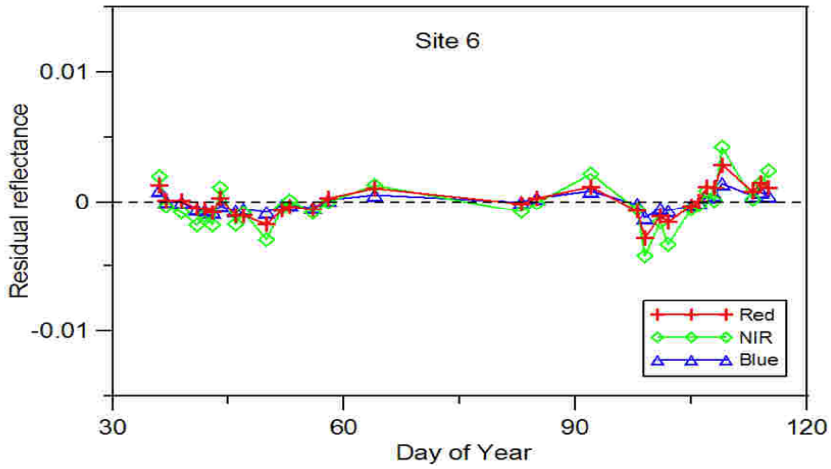


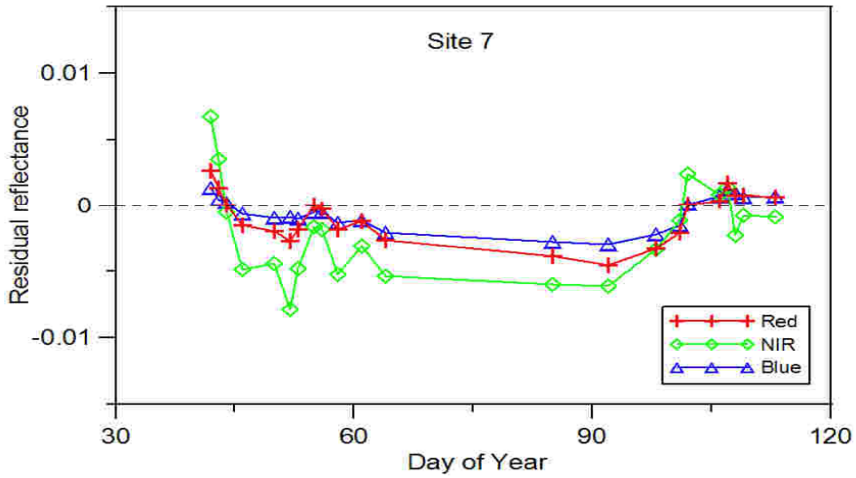
70-90% density

Example MODIS Time Series – Seasonal Profiles as a function of Juniper land cover type and density. Google Earth images depict site locations.

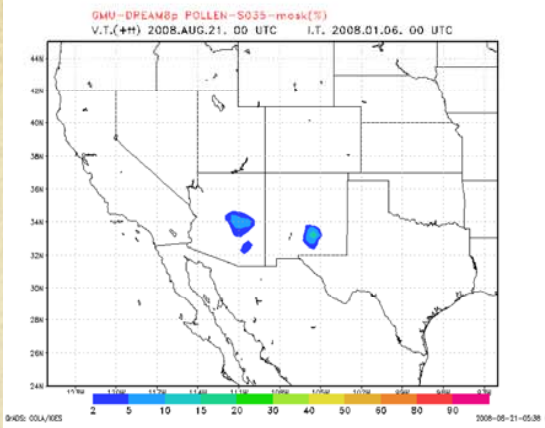




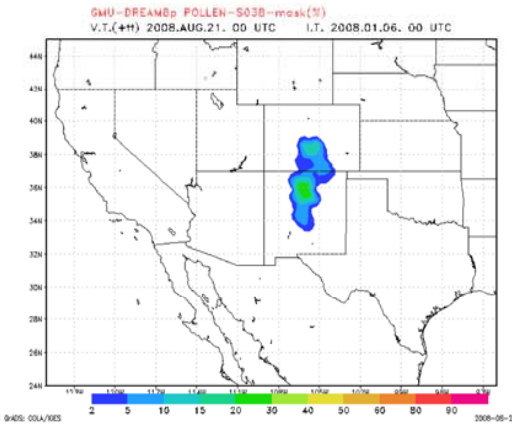




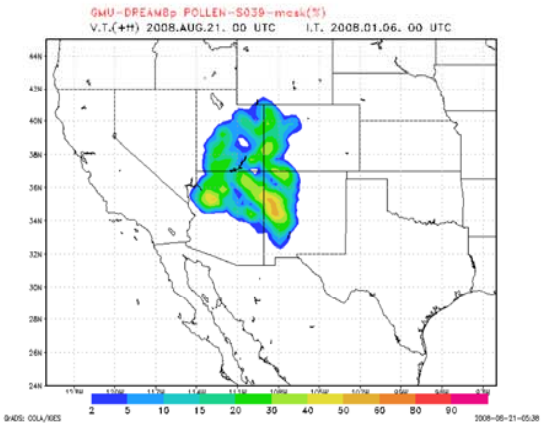
Temporal profiles of residual MODIS reflectances at the four study sites.



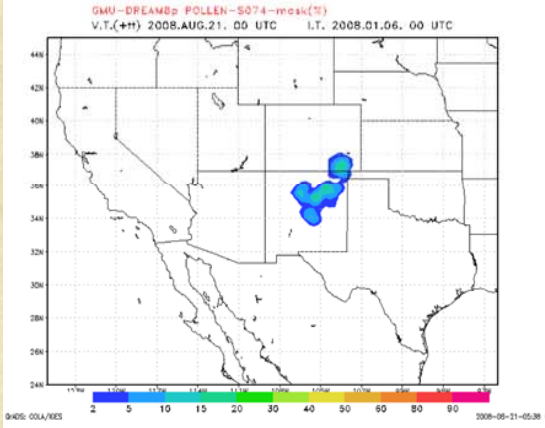
S035



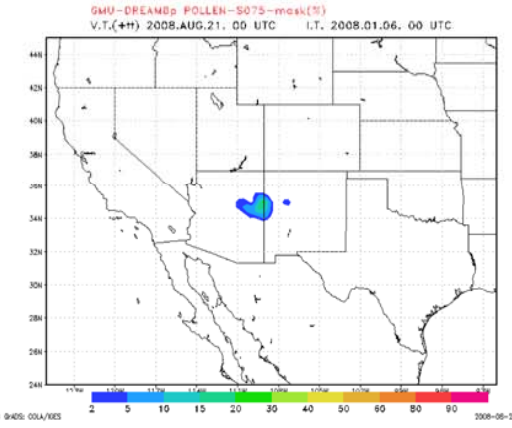
S038



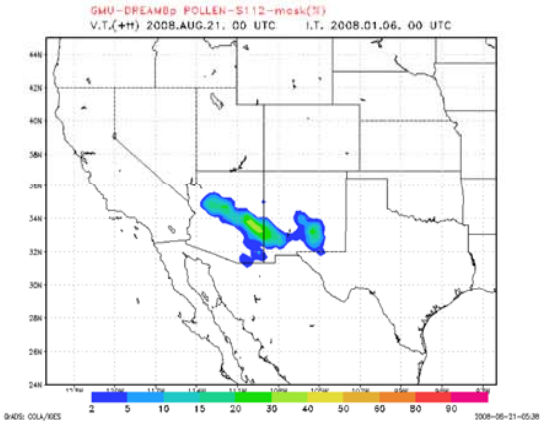
S039



S074

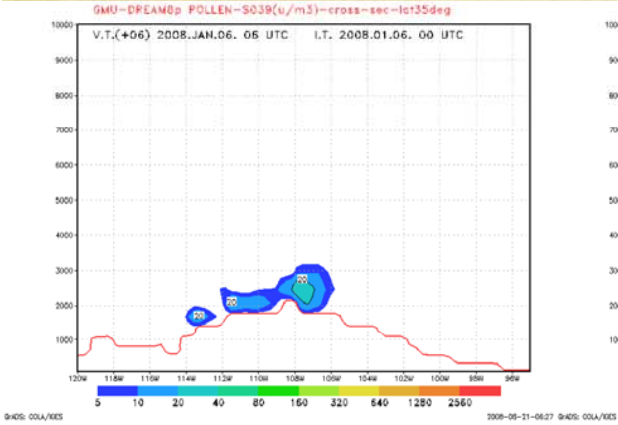


S075

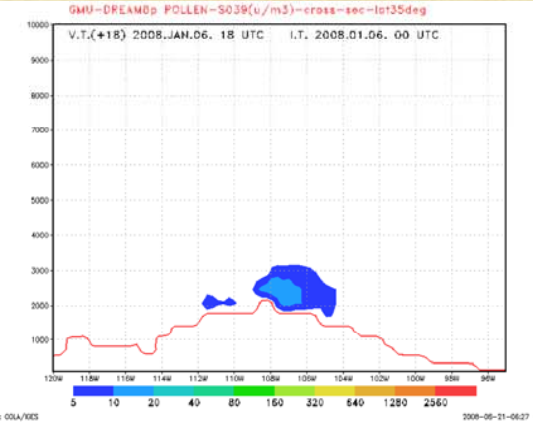


S112

Pollen sources as the model see them (six juniper classes)



6 Jan 2008 + 06hr



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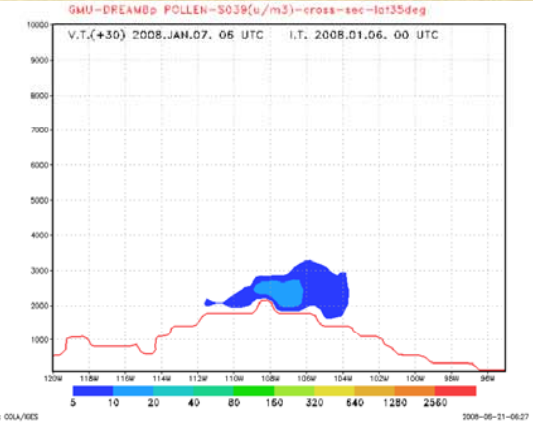

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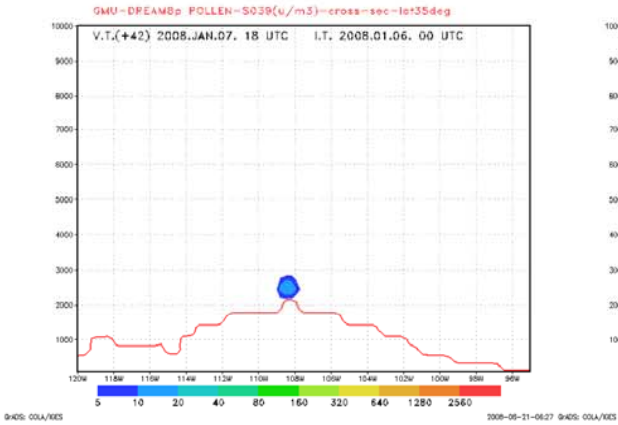
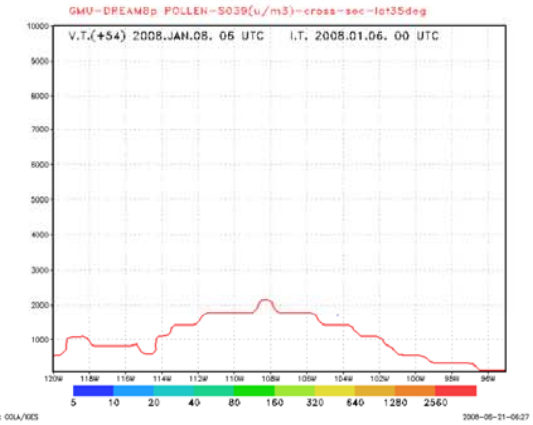
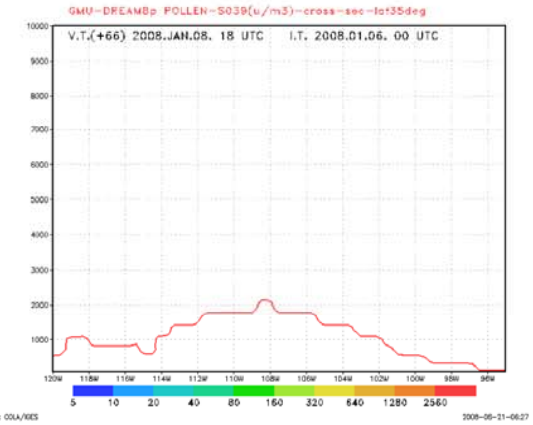


6 Jan 2008 + 42hr



6 Jan 2008 + 54hr



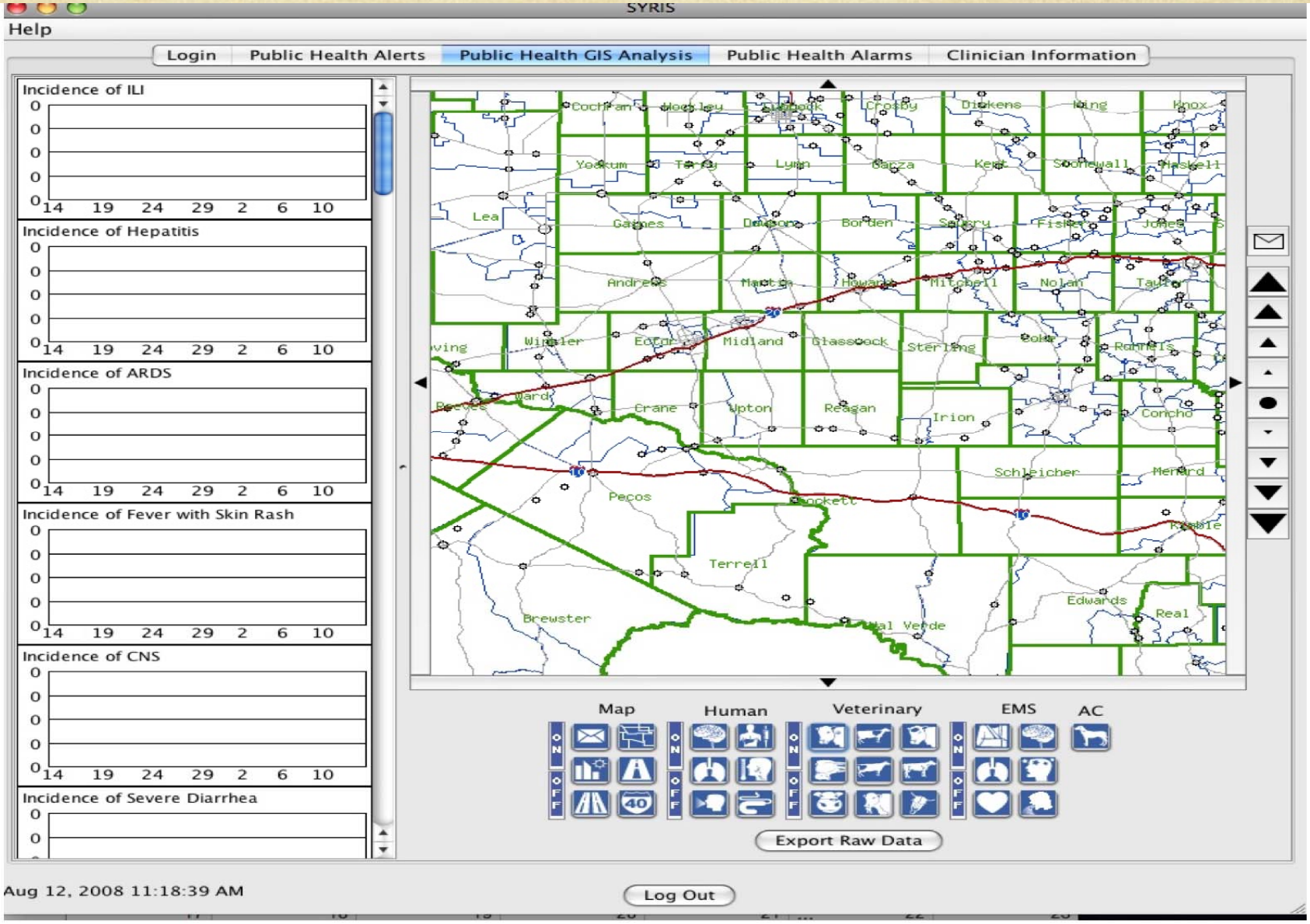
6 Jan 2008 + 66hr

Pollen concentration simulation for the S039 juniper class; section crossing at 35 deg N

Syndrome Reporting Information System™

The SYRIS system provides:

- Real-time, Syndrome-Based Reporting Tool
- 2-Way Real-time Communication System - 24/7
- Automated, Immediate 'Alerts' to Public Health Officials (PHO's)
- Health 'Alerts' to Vets, Doctors, Hospitals, & Schools
- Web-Based Tool for Easy Syndrome Entry and Communication
- Geographic Mapping of Disease Outbreaks
- Connects All Health Care Providers to a Common Database
- Instantaneous Geographic Mapping of Disease Outbreaks
- Full compliance with the requirements of Public Law 109-417 (the Pandemic and All-Hazards Preparedness Act)



SYRIS will be used by Public Health Officials for interactive display of PREAM pollen maps, syndrome reporting and alerts

Source Questions:

Pollen emission is controlled mainly by near-surface atmospheric conditions. Critical questions about pollen release and transport needed to be addresses to provide necessary data for verifying and validating PREAM inputs and outputs.

✧ What are the meteorological conditions that promote continual pollen release?

✧What is the quantity and pollen size distribution at time of release?

✧What is the effect of hydroscopic and weight gain on transport?

✧How can we verify our estimates of pollen production and transport?

✧What is the size and density of juniper populations? What is the percent of male trees in the population?

✧What percent of pollen is deposited beneath the tree and never entrained in the atmosphere?

Conclusions

✓The residual signal indicates that the pollen event may influence the seasonal signal to an extent that would allow detection, given accurate QA filtering and BRDF corrections. MODIS daily reflectances increased during the pollen season.

✓ The DREAM model (PREAM) was sucessfully modified for use with pollen and may provide 24-36 hour running pollen forcasts.

✓Publicly available pollen forecasts are linked to general weather patterns and roughly-known species' phenologies. These are too coarse for timely health interventions. PREAM addresses this key data gap so that targeting intervention measures can be determined temporally and geospatially.

✓The New Mexico Department of Health (NMDOH) as part of its Environmental Public Health Tracking Network (EPHTN) would use PREAM a tool for alerting the public in advance of pollen bursts to intervene and reduce the health impact on asthma populations at risk.